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POSITIONAL VARIATIONS AND MODIFICATIONS RELATING TO THE PROTERGUM IN HYMENOPTERA

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Introduction

The present work is a part of a general research project concerned with the tracing of evolutionary trends related to various body features within the entire range of the order Hymenoptera. This work specifically includes observations dealing with the gradual changes in the position of the protergum, which in higher Hymenoptera shifts backwards to become closely associated with the anterior margin of the mesothorax. The extent and magnitude of this association varies, and these variations form a systematic graded pattern which cannot be without evolutionary significance. This study also throws some light on phylogenetic relations among the different families of this insect order. Thus far no comprehensive study has been undertaken indicating the succession of these changes which affects the thoracic topography in Hymenoptera. In 1910 Snodgrass recorded some observations pertaining to the changes in the hymenopterous thorax as a whole, but his observations were based on only eight families. The following authors also referred to this thoracic component, but without discussing the magnitude of its shift from any comparative angle: Snodgrass (1910, 1925), Bird (1926), Reeks (1937), Duncan (1939), Alam (1951), Arora (1953), Rivard (1955), Bracken (1961), Tait (1962), Wong (1963), Dhillon (1966) and Matsuda (1970). However, the present study which is based on observations made on the various hymenopterans belonging to about 20 different families of this insect order, does exactly this.

Summary

In Pamphiliidae and Xyelidae the protergum with its small antero-lateral angles is loosely attached to the mesotergum and the membranous areas prominently intervene between its posterolateral sides and the mesoepisternum. The protergum, however, in Tenthredinidae, Diprionidae, Argidae, Cimbicidae, Cephidae, Xiphydridae and Siricidae is extended at its anterolateral angles and is rather more closely attached to the mesotergum. The above mentioned membranous areas are also considerably reduced. The chalcidoidea present further advancement in this trend, in which case the protergum is closely applied to the mesotergum and the membranous areas are mere interposing spots. In Ichneumonoidea the antero-lateral angles of the protergum are further extended antero-ventrally giving the pro-

tergum a collar-like appearance which on its postero-lateral sides abuts against the adjoining margin of the mesopectus thus leaving no trace of intervening membranous areas. A similar condition prevails in the males of Formicidae and Mutillidae, but in the females the protergum is secondarily fused with the mesotergum and mesopectus. Another line of modification is represented by Chrysididae, Scoliidae, Vespidae and Eumenidae, where, besides the considerable extension of the antero-lateral angles of the protergum, its postero-lateral angles also extend laterally in the form of spiracular lobes to cover the first pair of the spiracles. These modifications are further magnified in Sphecidae, in which the further extended antero-lateral angles of the protergum imparts to the latter an appearance of a pronounced collar. However, here the two opposite ends of the collar just touch but do not fuse. In Apoidea the opposite ends of the collar-shaped protergum fuse with each other and exist in the form of an entire annulus completely girdling the anterior margin of the mesothorax.

Material and Methods

To carry out the present study, most of the specimens of Apocrita were collected from the Punjab and Himachal Pradesh during the months of September and October 1975 and preserved in 80% alcohol. Symphyta, with the exception of Megalodontidae and Orussidae, were supplied by the Biosystematic Research Institute, Canada, and the Zoological Survey of India. As the specimens provided by them were dry, they were softened by immersion in 2% KOH for about 6 days. Diagrams were drawn with the help of a Stereoscopic microscope fitted with a graph eye-piece.

OBSERVATIONS AND DISCUSSION
(Figs. Plate I, II)

The sequential separation of the protergum from the propectus and its complete integration with the anterior margin of the mesothorax is a characteristic feature of the order Hymenoptera. This disassociation probably was initiated among the ancestors of the suborder Symphyta but it reached its climax in the higher apocritans where the protergum seems to be more an integral part of the mesothorax than of the prothorax. In the females of the families Formicidae and Mutillidae, the protergum is completely fused with the mesothorax and even the line of fusion is quite obscure. This fact reveals a trend of considerable evolutionary significance. An effort has been made to work out in sequence all the stages of the shift as represented in the position of the protergum vis-a-vis the propectus and the mesotergum in extant families.

The most primitive known condition is observed in the members of the families Pamphiliidae and Xyelidae. In *Acantholyda maculiventris* (Fig. 1)

FIG. 1

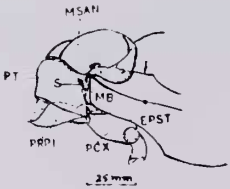


FIG. 2

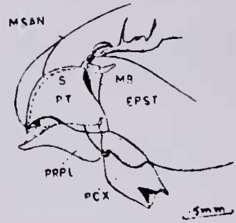


FIG. 3

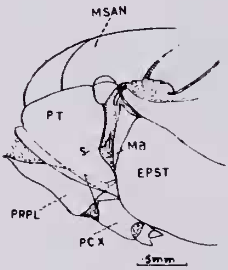


FIG. 4

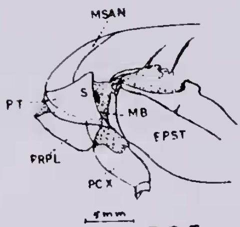


FIG 5

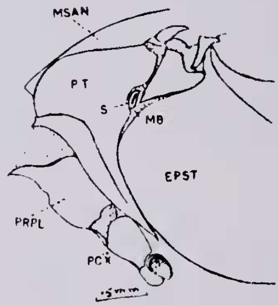


FIG 6

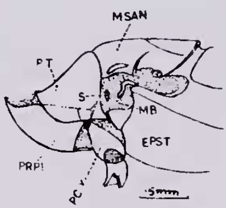


FIG. 7

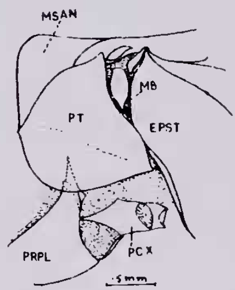


FIG. 8

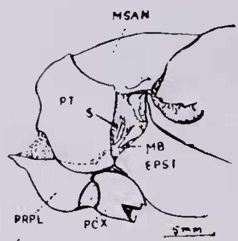


FIG. 9

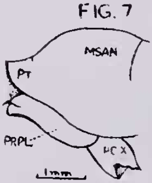


FIG. 34

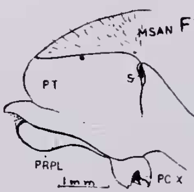


FIG 35

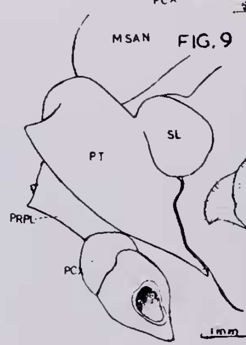


FIG. 36

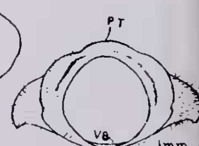
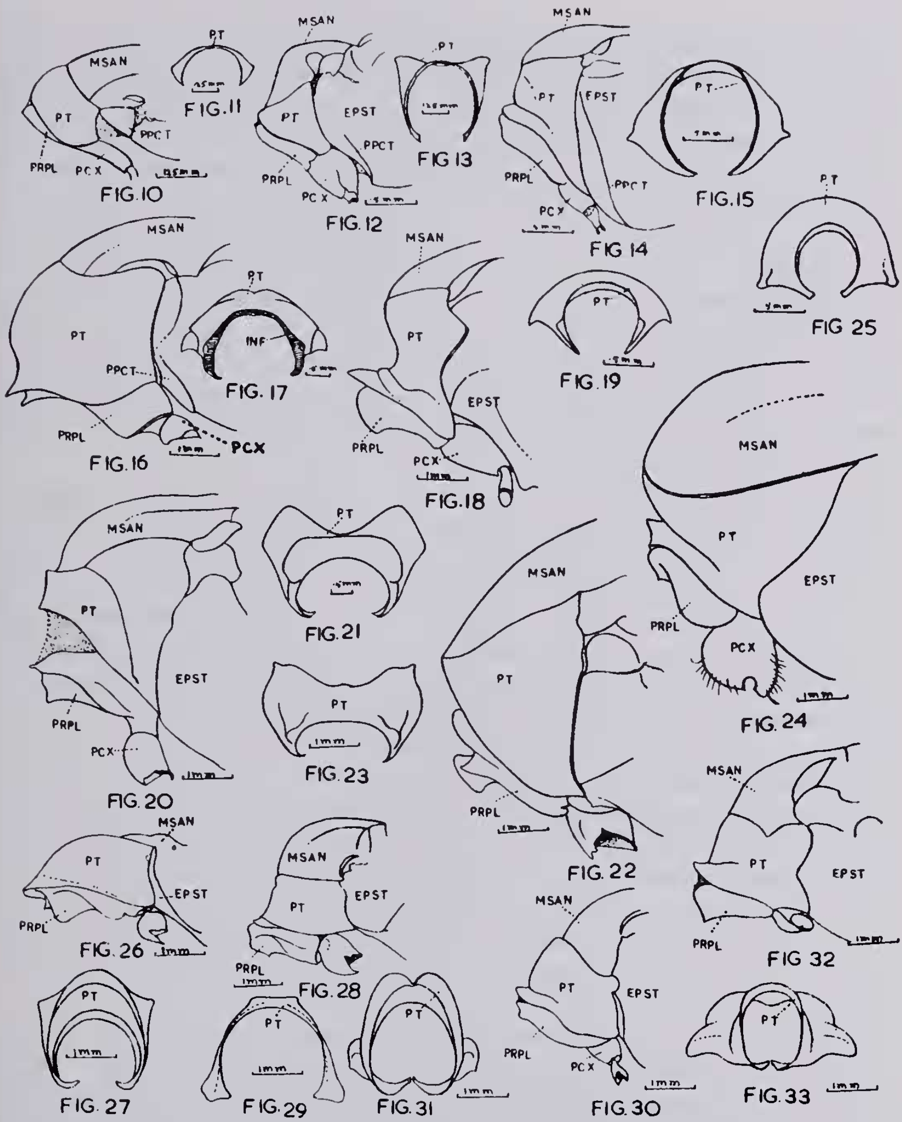


FIG. 37

Side view of the protergum and its association with the mesothorax. 1. *Acantholyda maculiventris*; 2. *Xyela bakeri*; 3. *Neodiprion abietis*; 4. *Arge clavicornis*; 5. *Pristiphora cincta*; 6. *Cimbex americana americana*; 7. *Cephus (Cephus) cinctus*; 8. *Xiphydria mellipes*; 9. *Sirex cyaneus*; association of the protergum with mesothorax and the front view of the protergum;



10, 11. *Sycoscapter stabilis*; 12, 13. *Netelia kashmirensis*; 14, 15. *Trachysphyrus* sp.; 16, 17. *Chrysis indogotea*; 18, 19. *Scolia quadripustulata*; 20, 21. *Vespa orientalis*; 22, 23. *Eumenes dimidiatepennis*; 24, 25. *Dorylus labiatus*; 26, 27. *Sima rufonigra*; 28, 29. *Camponotus camelinus*; 30, 31. *Scelephron intrudens*; 32, 33. *Stizus vespiformis*. Side view of the protergum and its association with the mesothorax; 34. female *Dorylus labiatus*; 35. female *Mutilla* sp.; association of the protergum with mesothorax and the front view of the protergum. 36, 37. *Xylocopa lemuiscapa*.

Abbreviations

EPST—Episternum; INF—Inflection; MSAN—Mesalinotum; MR—Membrane or (Membranous); PCX—Procoxa; PPCT—Prepectus; PRPL—Propleuron; PT—Protergum; S—Spiracle; SL—Spiracular lobe; VB—Ventral bridge.

(Pamphiliidae) and *Xyela bakeri* (Fig. 2) (Xyelidae) the protergum is weakly attached to the anterior margin of the mesonotum and also there are present membranous areas between its sides and the mesoepisternum. On the whole, the association of the pronotum with the mesothorax is not rigid and in this case it does not seem to be an integral part of the latter. A similar condition has also been observed in *Pamphilius luteicornis* and *Cephalcia provancheri* (Pamphiliidae). These observations are further substantiated by the similar work of Rivard (1955) on *Cephalcia marginata*. Matsuda (1970) has also described an equivalent condition in *Pamphilius luteicornis* but with the difference that he has shown the presence of a narrow bridge which connects the protergum and the mesoepisternum. However, close observation reveals that this bridge is not a sclerotic connection but is a forward extension of the mesoephisternum and which is distally in membranous connection with the protergum.

Conditions are different in the rest of the higher symphytans. In *Pristiphora cincta* (Fig. 5), *Pachyprotasis brunetti* and *Tomostethus* (*Eutomostethus*) *assomensis* (Tenthredinidae) *Neodiprion abietis* (Fig. 3) (Diprionidae), *Arge clavicornis* (Fig. 4) (Argidae), *Cimbex americana americana* (Fig. 6) (Cimbicidae), *Cephus* (*Cephus*) *cinctus* (Fig. 7) (Cephidae), *Xiphydria mellipes* (Fig. 8) (Xiphydridae) and *Sirex cyaneus* (Fig. 9) (Siricidae), the protergum is closely attached to the mesotergum and the membranous area between it and the mesoepisternum is reduced further.

The antero-lateral angles of the protergum are drawn out in the form of a triangular extension reaching far up to the base of the procoxa. As such it seems to be a part of the mesothorax girdling the latter anteriorly. An almost similar condition has also been shown by Snodgrass (1910) in *Arge* sp., *Tremex columba*, *Lygaenematus erichsonii*, Bird (1926) in *Hoplocampa halcyon*, Reeks (1937) in *Diprion polytomum*, Arora (1953) in *Diprion pini*, Bracken (1961) in *Anoplonyx luteipes*, Tait (1962) in *Perga affinis affinis*, Wong (1963) in *Pristiphora erichsonii* and Dhillon (1966) in *Athalia proxima*.

Members of the group Hymenoptera Parasitica show a further modification over the condition described up to this point. In *Sycoscapter stabilis* (Figs. 10, 11) (Torymidae-Chalcidoidea) the posterior margin of the protergum abuts against the mesotergum, thereby forging a tighter connection, and the membranous area between it and the episternum is further reduced. However, the ventral extensions of the antero-lateral angles of the pronotum are of the similar pattern as above. Similar observations have been made in the other chalcids studied including *Walkerella temeraria* and *Micranisa pteromaloides* (Torymidae), *Sycophila decatomoides* (Eurytomidae) and *Blastophaga masoni* (Agaonidae). Snodgrass (1910) has also shown a similar condition in the chalcids under his observation. In the members of the Superfamily Ichneomonoidea such as *Netelia kashmirensis* (Figs. 12, 13) and

Trachysphyrus sp. (Figs. 14, 15), further modifications to this effect are traceable. In them the ventral extension of the antero-lateral corners of the protergum is more pronounced. They reach far down on the sides, fitting into the space between the base of the procoxa and mesopleuron. Moreover the protergum is more firmly attached with the mesonotum than even in the case of the chalcids. Snodgrass (1910), Alam (1951) and Jonathan and Gupta (1973) have made similar observations.

In the male representatives of the families Formicidae (Figs. 24, 25 and 26 to 29) and Mutillidae, conditions are similar to those which prevail in ichneumonids but in the females of *Dorylus labiatus* (Fig. 34) (Formicidae) and *Mutilla* sp. (Fig. 35) (Mutillidae), conditions are further modified. The posterior and postero-lateral angles of the protergum have become completely fused with the corresponding anterior margin of the mesonotum, and this fusion is such that even the lines of fusion are not traceable. Studying only these insects, one can easily be misled to believe the protergum to be a part of the mesothorax. However, after comparing the female representatives with the males of these species, it becomes quite clear that in females the fusion of the protergum with the mesonotum is only a secondarily acquired character. The propectus lies much ahead and looks entirely disassociated from the protergum.

The second line of modification covers the rest of the families of suborder Apocrita. In *Chrysis indogotea* (Figs. 16, 17) (Chrysididae), *Scolia quadripustulata* (Figs. 18, 19) (Scoliidae), *Vespa orientalis* (Figs. 20, 21) (Vespidae), *Eumenes dimidiatepennis* (Figs. 22, 23) (Eumenidae), the conditions resemble very much those of the ichneumons. In them the postero-lateral angles of the protergum extend to cover the spiracles and these extensions can be compared with the spiracular lobe of the honeybee (Snodgrass, 1925). On the other hand, the antero-lateral angles of the protergum are almost equal to those seen in the ichneumons.

Conditions are further modified in the members of family Sphecidae. In *Scelephron intrudens* (Figs. 30, 31), *Stizus vespiformis* (Figs. 32, 33), the ventral extensions of the antero-lateral angles of the protergum are much more pronounced. These extensions, after flanking the sides, also extend on the ventral aspect of the prothorax so as to come close to one another along the mid-ventral line without actually fusing. Thus the entire pronotum appears to form a collar skirting the mesothorax along its anterior boundary. Prothoracic spiracles in these cases are completely covered over by the well developed spiracular lobes which extend laterally in the postero-lateral angles of the protergum. In the case of *Xylocopa lemuiscapa* (Figs. 36, 37), a member of superfamily Apoidea, ventral extension of the protergum, after flanking the sides of the segment, not only lie close to one another but they actually fuse to form a ventral plate between the prosternum and the mesosternum. In this way, the protergum forms an entire annulus which encircles the mesothorax along its anterior margin. In this process it gets far removed from the propectus as well, with which it has only membranous connection. The propectus occurs in a much forward position with only its posterior tip lying just in the enclosure of the protergum. Similar conditions have also been noted in some other unidentified specimens of this superfamily. This observation is further substantiated by similar studies made by Snodgrass (1910) in honeybee and in *Proctotrypes candatus*. This stage probably represents the most advanced stage of evolution as far as the disassociation of protergum from the propectus and the complete transformation of the former from a dorsal plate into an annular sclerite are concerned. This evolutionary stage is also seen in the association of the pronotum with its lateral extensions covering the two first spiracles in the form of lobes.

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